

Transmission characteristics— μ -Law

Transmission characteristics for IPE

Tables 9 through 22 provide the transmission characteristics for IPE.

Frequency response

Frequency response (attenuation distortion) at a given frequency is the difference between the loss at that frequency and the loss at 1000 Hz. Table 9 shows the minimum and maximum loss differences at significant frequency breakpoints for

- station to station interfaces and station to 2-wire trunk interfaces
- 4-wire analog trunk to 4-wire analog trunk interfaces

Table 9
Frequency response— μ -Law

Frequency (Hz)	Frequency response (dB)			
	Station to station/ station to 2-wire		4-wire to 4-wire	
	Minimum	Maximum	Minimum	Maximum
60	+20.0	—	+16.0	—
200	0.0	+5.0	0.0	+3.0
300	−0.5	+1.0	−0.3	+0.3
3000	−0.5	+1.0	−0.3	+0.3
3200	−0.5	+1.5	−0.3	+1.5
3400	0.0	+3.0	0.0	+3.0
Note: Positive values denote loss; negative values denote gain (measured at 1000 Hz with 0 dBm0 input level).				

Overload level

Overload levels are measured with respect to the zero-level point in the PBX, which is defined as having an overload point of +3 dBm in an analog to digital conversion.

Therefore, the overload level in the receive direction is defined as the analog signal level (at the port interface) with an average power that is 3 dB greater than that of the signal, which after encoding produces the equivalent of the digital milliwatt (PBX zero-level point).

The overload level in the transmit direction is defined as the analog signal level (at the port interface) with an average power that is 3 dB greater than that of the signal, which after decoding results from the equivalent of the digital milliwatt. **Table 10** shows the overload levels in both the receive and the transmit directions.

Note: The digital milliwatt is the digital representation of a 1 kHz signal at 0 dBm.

Table 10
Overload level— μ -Law

Type of circuit	Overload level (dBm)	
	Receive (analog to digital)	Transmit (digital to analog)
Line	+6.5	+2.5
CO trunk	+3.0	+6.0
Tie trunk	+3.5	+3.5
Tie (4-wire)	+3.0	+4.0
Note: For trunks, overload is specified for pads-out mode.		

Tracking error (gain variation with level)

Level tracking measures how closely changes in the level of the input signal cause corresponding changes in output level. Tracking error, as shown in Table 11, is the deviation, in decibels, in gain or loss through specified ranges of input level relative to the deviation of a nominal 1000-Hz input signal at the 0 dBm0 level.

Table 11
Tracking error (gain variation with level)— μ -Law

Input signal (dBm0)	Maximum tracking error (dB)	Average tracking error (dB)
0 to -37	± 0.5	± 0.25
-37 to -50	± 1.0	± 0.5
Note: The input signal level is referenced to the zero relative power level (dBm0).		

Return loss

Return loss at an impedance discontinuity in a transmission path is the ratio, in decibels, of the power level of an incident signal to the power level of the resulting reflected signal. Echo return loss (ERL) is a weighted average of the return loss values over the frequency range of 500 to 2500 Hz.

Single-frequency return loss (SFRL) is the lowest value of nonweighted return loss occurring in the frequency range of 200 to 3200 Hz.

Table 12 shows the return loss needed to satisfy the in-service parameter values shown in Table 13. For each interface type (line and 2-wire trunk), a connection is made through the PBX to a 4-wire trunk interface, and the return loss is measured at both interfaces. Terminating impedance is 600 ohms for all IPE cards.

For the EPE cards, the terminating impedance, as measured from MDF to MDF, is:

- 600 Ω for Meridian 1 lines and 4-wire trunks
- 600 Ω and 2.16 μF for PBX lines
- 600 Ω /900 Ω and 2.16 μF for 2-wire trunks

Table 12
Return loss—design parameter values— μ -Law

Connection	Echo return loss (dB)	Single-frequency return loss (dB)
Line interfaces:		
line side	>18	>12
4-wire trunk side	>25	>19
2-wire trunk interfaces:		
2-wire trunk side	>22	>17
4-wire trunk side	>28	.22

Table 13
Return loss—in-service parameter values— μ -Law

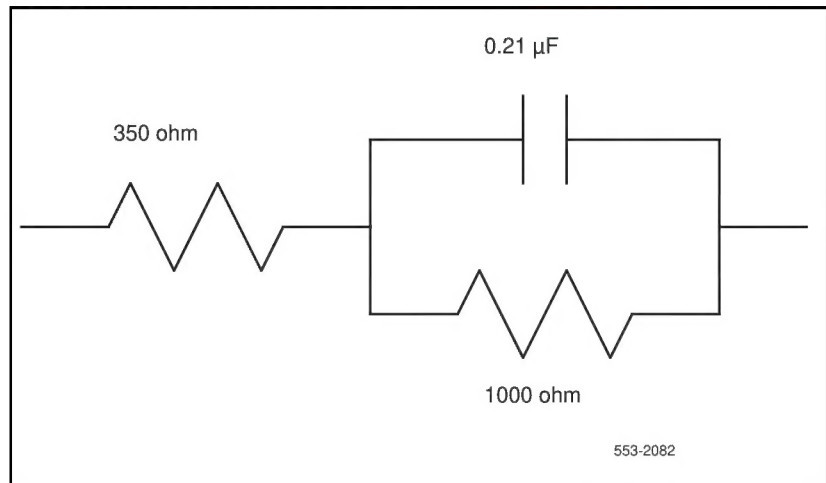
Connection from 4-wire VNL tie trunk to:	Circuit termination	Echo return loss (dB)	Single-frequency return loss (dB)	Notes
4-wire VNL tie trunk	4-wire legs of hybrid terminated in 600 Ω	>27	>20	1, 3
4-wire non-VNL tie trunk	600 Ω at tip/ring of channel in distant PBX	>22	>15	1, 3
2-wire non-VNL tie trunk	600/900 Ω at tip/ring of channel in distant PBX	>18	>10	1, 4
CO or FX trunk (TRC)	900 Ω at CO	>18	>10	2, 3
PBX station line	600 Ω	>24	>18	1, 5
PBX station line	Station off-hook	>12	>8	1, 5
Note 1: Reference impedance is 600 Ω. Note 2: Reference impedance is 900 Ω. Note 3: Nominal trunk to trunk loss is 0 dB. Note 4: Nominal trunk to trunk loss is 0.5 dB. Note 5: Nominal loss is 3.5 dB, trunk to station; 2.5 dB, station to trunk.				

Transhybrid loss

Impedance mismatches between hybrid compromise networks and 2-wire terminations (line or trunk) may result in instability and listener echo degradations in the 4-wire switching path of a digital PBX. The echo return loss requirements presented in [Tables 12](#) and [13](#) do not adequately address this problem. Thus, for digital PBXs, requirements are placed on the return loss at the hybrid between the 2-wire interface and the 4-wire switching path. This requirement is called transhybrid loss.

Two-wire ports with external facilities present a distribution of impedances to the PBX interface. To effect a good match with this distribution and to achieve the transhybrid loss specifications shown in [Table 14](#), a three-element compromise impedance network is used in 2-wire analog trunk ports to balance the impedance of the trunk (see [Figure 1](#)).

Figure 1
Compromise impedance network



Transhybrid loss is measured from a balanced 4-wire port (with transmit and receive legs at equal level) to the 2-wire port. The 2-wire port is terminated in a compromise impedance network that consists of 600 ohms (for stations) or the network in [Figure 1](#) (for 2-wire trunks). [Table 14](#) gives the minimum transhybrid loss over the indicated frequency ranges for input signals at the 4-wire port.

Table 14
Transhybrid loss— μ -Law

Two-wire port	Transhybrid loss (dB)	
	200 to 3400 Hz	500 to 2500 Hz
Line	>17	>19
Trunk	>18	>21

Input impedance

Input impedance (see [Table 13](#)) for a 2-wire port of a digital PBX is the impedance seen looking into the port from an external source. The requirements shown in [Table 15](#) pertain to the minimum return loss of the port when

- the return loss is measured with a return-loss test set terminated with a specified reference impedance at the PBX
- the port is connected through the PBX to a 4-wire port with 600 ohms termination

The return loss is a function of frequency and increases without limit as the port input impedance approaches the reference impedance.

Table 15
Input impedance— μ -Law

Path through PBX to 4-wire trunk from 2-wire port	Reference impedance	Frequency range (Hz)	Minimum return loss (dB)
Line	600 Ω	200–500	20
		500–3400	26
Trunk	600 Ω	200–500	20
		500–1000	26
		1000–3400	30
Note: For trunks, the minimum return loss specifications are supported for the 600-ohm termination option of the trunk. The specifications are not supported for the 900-ohm termination option.			

Idle channel noise

Idle channel noise (noise in the absence of a signal) is the short-term, average, absolute noise power, measured with either C-message weighting or 3000 Hz flat weighting, as shown in [Table 16](#).

- C-message weighting measures noise with a frequency weighting that reflects the characteristic of the human ear.
- 3000-Hz flat weighting measures noise with equal weighting for all frequencies in the 200–3000 Hz frequency range, measured at the PBX tip and ring.

Table 16
Idle channel noise— μ -Law

Connection type	C-message weighted noise (dBrnC)			3000-Hz flat noise (dBrn)
	Analog to analog	Analog to digital	Digital to analog	
Line to line	< 20	< 15	< 13	< 29
Line to trunk *	< 20	< 15	< 13	< 29
Line to CO trunk at trunk port	< 23	< 16	< 16	< 29
Trunk to trunk	< 20	< 15	< 13	< 29
*At the line port or at the tie trunk port				

Longitudinal balance

Longitudinal balance (longitudinal to metallic), as shown in **Table 17**, defines the amount of metallic noise voltage (conductor to conductor) resulting from longitudinal voltage (conductor to ground) at the circuit input. The equation for calculating longitudinal-to-metallic balance is as follows:

$$\text{longitudinal balance (dB)} = 20 \log [V_s/V_m]$$

Note: V_s is the disturbing longitudinal voltage, and V_m is the resulting metallic voltage of the same frequency. Ideally, the metallic noise voltage is negligible and the longitudinal balance approaches infinity. All measurements are at the PBX tip and ring.

Table 17
Longitudinal balance— μ -Law

Frequency (Hz)	Minimum balance (dB)	Average balance (dB)
200	58	63
500	58	63
1000	58	63
3000	53	58

Crosstalk

Crosstalk is the presence of unwanted voice signals coupled from one voice channel to another. Crosstalk not only is an annoyance to the listener but also is perceived as a violation of privacy. The crosstalk coupling attenuation for every combination of through connections in all interface categories, measured with input signals from 200 to 3200 Hz at 0 dBm0, are listed in [Table 18](#).

Table 18
Crosstalk— μ -Law

Connection	Minimum crosstalk attenuation (dB)
Line to line	> 75
Line to trunk	> 75
Trunk to trunk	> 75

Quantization distortion

Quantization distortion is the distortion introduced when an analog signal is encoded to digital format, then decoded to analog format. The quantization noise is the difference between the original analog speech signal and the analog signal (speech plus noise) resulting from the decoding process.

Table 19 shows the minimum signal-level to distortion-level ratio values for 1000-Hz sine-wave input signal levels and C-message weighted output (distortion) levels.

Table 19
Quantization distortion— μ -Law

Input signal level (dBm0)	Minimum signal-distortion ratio (dB)	
	Analog to analog	Digital to analog or analog to digital
+0 to -30	33	35
-30 to -40	27	29
-40 to -45	22	25

Intermodulation distortion

Intermodulation distortion is caused by nonlinearities present in the electric-to-electric transfer function of the PBX. This form of distortion primarily affects data transmission.

Intermodulation distortion is measured by using the four-tone method that employs two pairs of equal-level tones transmitted at a total, composite power level of -13 dBm. One pair of tones uses 857 Hz and 863 Hz frequencies, while the second pair uses 1372 Hz and 1388 Hz frequencies. The second- and third-order products of distortion are denoted as R2 and R3, respectively.

The power levels for R2 and R3 (see [Table 20](#)) are expressed in decibels below the received power level and are calculated as follows:

- R2 is the average power level measured in two different ranges of the voiceband between 503 Hz and 537 Hz, and between 2223 Hz and 2257 Hz.
- R3 is the total power level in the frequency range between 1877 Hz and 1923 Hz.

Table 20
Intermodulation distortion— μ -Law

Connection type	Distortion limits (dB) below received level		Test-signal input level (dBm)
	R2	R3	
Line to line	39	51	-9
Line to trunk	39	51	-9 at line
			-13 at trunk
Trunk to trunk	39	51	-13

Envelope delay

Envelope delay in a system is the propagation time through the system of a low-frequency sinusoidal envelope of an amplitude-modulated sinusoidal carrier. The carrier frequency is varied throughout the frequency range of interest to obtain the envelope delay as a function of frequency.

Relative envelope delay is the difference between the envelope delay at a given frequency and the global minimum envelope delay within the frequency range. The values in [Table 21](#) indicate the relative envelope delay for the frequency ranges shown.

Table 21
Relative envelope delay— μ -Law

Bandwidth (Hz)	Relative envelope delay (μ s)	
	Line to line	Line to trunk and trunk to trunk
800 to 2700	750	375
1000 to 2600	380	190
1150 to 2300	300	150

Impulse noise

Impulse noise is noise bursts or spikes that exceed normal peaks of idle-channel noise. Impulse noise is measured by counting the number of spikes exceeding a preset threshold over a defined time duration. Over a five-minute interval, the number of counts above 55 dBnC is zero under fully loaded busy-hour PBX traffic conditions.

Echo path delay

Echo path delay is the maximum round-trip port to port delay for all frequencies in the 200–3400 Hz range (see [Table 22](#)).

Table 22
Echo path delay— μ -Law

Path	ms
Analog to analog	3.0
Analog to digital	2.4
Digital to digital	2.0

Transmission characteristics for PE

The transmission characteristics for PE are the same as for IPE (see [Tables 9](#) through [22](#)) except for the following characteristics.

Overload level

The overload levels for PE with trunks in pads-out mode are listed in [Table 23](#).

Table 23
Overload level— μ -Law

Port	Receive (analog to digital)	Transmit (digital to analog)
Line	+7.0	+2.0
CO trunk	+3.0	+6.0
2-wire and 4-wire tie trunk	+3.0	+6.0
Tie (4-wire)	+2.5	+6.5

Return loss

The requirements for return loss of PE are the same as those for IPE (see [Tables 12](#) and [13](#)), however, the conditions for the requirements listed in [Table 13](#) are modified as follows:

- The nominal loss for a tie trunk (2-wire or 4-wire, VNL or non-VNL) to or from a 4-wire tie trunk is 0 dB.
- The nominal loss for a CO/FX trunk to or from a 4-wire tie trunk is 0.5 dB.
- The nominal loss for a station line (including an SL-1 telephone line) to or from a 4-wire tie trunk is 2.5 dB.

Note: The preceding conditions are based on 4-wire tie trunk ports utilizing trunk card vintage QPC237C or later for North America and QPC296C or later internationally.

Transhybrid loss

The trunk specifications for transhybrid loss (see [Table 14](#)) apply to PE trunks that are compatible with Electronic Industries Association (EIA) specifications.

Input impedance

The trunk specifications for input impedance (see [Table 15](#)) apply to PE trunks that are compatible with EIA specifications.